PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application Of:	Matthew A. Purdy	Examiner:	Marc M. Duncan
Serial No.:	10/810,037	Group Art Unit:	2113
Filed:	3/26/04	Att'y Docket:	2000.113500
		Client Docket:	TT5607
For:	M/A For Predicting Yield Parameters Based On Fault Classification	Confirmation No.:	8441

APPEAL BRIEF

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants hereby submit this Appeal Brief to the Board of Patent Appeals and Interferences in response to the Final Office Action dated September 12, 2006 and the Notice of Appeal dated November 2, 2006.

The Commissioner is authorized to deduct the fee for filing this Appeal Brief ($500.00) and any other fees required under 37 C.F.R. §§ 1.16 to 1.21 from the Williams, Morgan & Amerson, P.C. Deposit Account No. 50 0786/2000.113500/SKS.

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I. REAL PARTY IN INTEREST

Advanced Micro Devices, Inc., the assignee hereof, is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences of which Applicants, Applicants' legal representative, or the Assignee is aware of that will directly affect or be directly affected by or have a bearing on the decision in this appeal.

III. STATUS OF THE CLAIMS

Claims 1-29 are pending. Claims 1-5, 7-18, and 20-27 are rejected. Claims 6 and 19 are objected to as depending from a rejected base claim, but would be allowable if presented in independent form. Claims 28 and 29 are allowed. Thus, claims 1-27 are the subject of this appeal.

IV. STATUS OF AMENDMENTS

A response to the Final Office Action was entered on May 9, 2007. This response included no amendments. All previous amendments have been entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

As described on starting on page 7, line 4, a network 20 interconnects various components of a manufacturing system 10, allowing them to exchange information. The illustrative manufacturing system 10 includes a plurality of tools 30-80. Each of the tools 30-80 may be coupled to a computer (not shown) for interfacing with the network 20. The tools 30-80 are grouped into sets of like tools, as denoted by lettered suffixes. For example, the set of tools 30A-30C represent tools of a certain type, such as a chemical mechanical planarization tool. A particular wafer or lot of wafers progresses through the tools 30-80 as it is being manufactured, with each tool 30-80 performing a specific function in the process flow. Exemplary processing tools for a semiconductor device fabrication environment include metrology tools, photolithography steppers, etch tools, deposition tools, polishing tools, rapid thermal processing tools, implantation tools, *etc*. The tools 30-80 are illustrated in a rank and file grouping for illustrative purposes only. In an actual implementation, the tools 30-80 may be arranged in any

physical order or grouping. Additionally, the connections between the tools in a particular grouping are meant to represent connections to the network 20, rather than interconnections between the tools 30-80.

As described starting on page 9, line 11, a process control server 90 stores information related to the particular tools 30-80 (*i.e.,* or sensors (not shown) associated with the tools 30-80) used to process each lot of wafers in the data store 110. As metrology data is collected related to the lot, the metrology data and a tool identifier indicating the identity of the metrology tool recording the measurements is also stored in the data store 110. The metrology data may include feature measurements, process layer thicknesses, electrical performance, surface profiles, *etc*. Data stored for the tools 30-80 may include chamber pressure, chamber temperature, anneal time, implant dose, implant energy, plasma energy, processing time, *etc.* Data associated with the operating recipe settings used by the tool 30-80 during the fabrication process may also be stored in the data store 110. For example, it may not be possible to measure direct values for some process parameters. These settings may be determined from the operating recipe in lieu of actual process data from the tool 30-80.

The manufacturing system 10 includes a fault detection unit 120 executing on a work-station 130 and a fault classification unit 140 executing on a workstation 150. In general, the fault detection unit 120 identifies fault conditions in the manufacturing system 10 and the fault classification unit 140 classifies the identified faults. A yield estimation unit 160 executing on a workstation 170 receives fault classification data from the fault classification unit 140 and generates a yield parameter based on the fault classification.

As described starting on page 11, line 10, the fault classification unit 140 uses fault detection data to separate faults into different categories, or "bins." Typically, each of the fault classes corresponds to a specific fault mechanism on the associated tool, such as a failure of an electrostatic chuck for holding a wafer, a failure in the gas system, a failure in the RF power system, *etc*. Each of these fault mechanisms may have a characteristic impact on yield parameters, such as overall yield, defectivity, or device performance.

The yield estimation unit 160 receives the fault classification data from the fault classification unit 140 and employs a yield estimation database 180 to match fault classes to estimated yield parameters. Although the yield estimation database 180 is illustrated as a separate entity, it may exist as part of the central data store 110. The yield estimation unit 160

may use one or more yield-related effects models to predict one or more yield parameters, such as overall yield, speed, defectivity, *etc*.

The yield estimation unit 160 may quantify yield impact in a variety of ways. In one embodiment, the yield estimation unit 160 may estimate the impact of a fault in a given fault class on systematic yield (*e.g.*, yield related to how the device functions), defect based yield (*e.g.*, whether the device functions at all), or both. The yield estimation unit 160 may quantify the yield impact as the number of die lost, the percentage of yield loss compared to material that did not have the fault, a speed likelihood or distribution, *etc*. As shown in Figure 3, in one hierarchy 300 for the yield estimation database 180, for each fault class (FC) 310-330 there is are associated yield parameters (YP) 340-380. Certain fault classes, *e.g.*, FC4 330 may have more than one associated yield parameter, *e.g.*, YP4A 370 and YP4B 380 to address the situation where a particular fault affects yield in a more than one way (*e.g.*, overall yield impact and speed impact).

The yield estimation unit 160 may use correlations between fault class and yield impact that are developed and updated in an automated fashion based on historical data. For example, any time a lot is sorted (*i.e.,* its yield is determined), the estimates for yield impact of any fault classes that wafer encountered could be updated. For example, a yield loss estimate for a given fault class (*e.g.*, FC1 310) may be 10%. If a current wafer having a fault in the same class has a yield loss of 15%, the yield parameter estimate (*e.g.*, YP1 340), tracked by the yield estimation unit 160 for the fault class may be updated using an averaging technique (*e.g.*, straight average, weighted average, exponentially weighted average, *etc*.).

In some cases, as illustrated in the hierarchy 400 of Figure 4, context data regarding the particular process being performed may be included in the analysis by the yield estimation unit 160. For example, a particular tool type may be used to perform multiple different processes on a wafer during the fabrication process. A fault at one step may have a different impact on yield than a similar fault occurring at a different step. For each fault class (FC) 410, 415 and process/step (PS) 420-440 combination, one or more yield parameters (YP) 445-465 may be tracked in the yield estimation database 180. Hence, the yield estimation unit 160 may generate separate yield threads for each process/step and potential fault condition. For example, a yield thread 470 would include FC6 420, PS4 435, and YP8 460.

The yield estimation unit 160 may track yield estimates for a given wafer or lot individually by fault occurrence. For example, the yield estimation unit 160 may generate a report for the wafer listing all the faults experienced and yield estimates for each fault class. In another embodiment, the yield estimation unit 160 may combine the yield estimates for the individual faults to generate an overall yield estimate. Various techniques may be employed for combining the yield estimates. For example, if the yield impacts are determined as a number of die lost for each fault classification, the yield estimation unit 160 may combine the impact by calculating a sum of all anticipated die lost. If the yield impacts are determined as an expected percent yield loss, then the yield estimation unit 160 may combine the impact by calculating the product of expected yield from each fault classification. Expected yield is calculated as 1 minus the percent yield loss.

Based on the yield estimates, the yield estimation unit 160 may implement automatic actions, or may recommend possible actions to an operator or fabrication manager. The particular actions taken upon identifying a fault class with an associated yield correlation may depend on the particular correlation. If the fault class signifies an increase in yield loss related to defectivity outside a predetermined acceptable range, the yield estimation unit 160 may recommend removing the processing tool 30-80 from production for maintenance. If the fault class has an associated significant overall yield loss, the yield estimation unit 160 may recommend canceling any future processing on the wafer (*i.e.,* scraping the wafer), because the predicted future economic value of the devices on the wafer is less than the expected cost to process the wafer to the end of the line.

Thus, with respect to claim 1, a method, the claimed subject matter includes:

- receiving fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool (30-80) for processing a wafer; and [Page 11, lines 10 – 22]
- estimating at least one yield parameter of the wafer based on the fault classification data. [Page 11, line 24 – Page 14, line 2]

With respect to claim 14, a system, the claimed subject matter includes:

- a fault classification unit (140) adapted to generate fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool (30-80) for processing a wafer; and [Page 11, lines 10 – 22]

- a yield estimation unit (160) adapted to estimate at least one yield parameter of the wafer based on the fault classification data. [Page 11, line 24 – Page 14, line 2]

With respect to claim 27, a system, the claimed subject matter includes:

- means for receiving fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool for processing a wafer; and [Page 11, lines 10 – 22]
- means for estimating at least one yield parameter of the wafer based on the fault classification data. [Page 11, line 24 – Page 14, line 2]

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Whether claims 1-5, 7-8, 10-18, 20-21, and 23-27 are obvious under 35 U.S.C. § 103(a) over Satya (U.S. Patent No. 6,751,519) in view of Hsieh (U.S. Patent Publication No. 2003/0060916).

Whether claims 9 and 22 are obvious under 35 U.S.C. § 103(a) over Satya and Hsieh in view of Atkinson (U.S. Patent Publication No. 2004/0029029).

VII. ARGUMENT

A. SATYA AND HSIEH FAIL TO OBVIATE ANY CLAIM

Claims 1-5, 7-8, 10-18, 20-21, and 23-27 were rejected under 35 U.S.C. § 103(a) as allegedly being obvious over Satya (U.S. Patent No. 6,751,519) in view of Hsieh (U.S. Patent Publication No. 2003/0060916).

Independent claims 1, 14, and 27 include the general features of receiving fault classification data associated with a tool fault condition. The tool fault condition is associated with a process tool for processing a wafer. At least one yield parameter of the wafer is estimated based on the fault classification data.

As the Office Action admits Satya fails to teach fault classification data associated with a tool fault condition. Satya teaches measuring yield characteristics of test structures formed on the wafer to estimate yield for the wafer. See col. 4, lines 59-63, for example. Hence, any fault detection contemplated by Satya relates to wafer fault detection, not tool fault detection.

Hsieh fails to correct this deficiency. Hsieh also measures wafer fault data. Hsieh tracks the tools that process a wafer so that wafer fault data can be linked back to a particular tool. Based on the application of Hsieh, it appears that the position of the Office Action is that Hsieh collects wafer fault data and then associates that data with a tool. This association does not meet the features of the claimed subject matter, even when Satya and Hsieh are combined. In contradistinction thereto, the claimed subject matter includes receiving fault classification data associated with a tool fault condition, where the tool fault condition is associated with a process tool for processing a wafer. Fault classification data specifies the nature of the tool fault condition. In fault detection and classification (FDC), data is collected associated with a tool. The data may include wafer data as well as tool state data. The collected data is then processed to identify a tool fault condition (*i.e.*, detection). Subsequently, the identified fault condition is classified to determine what type of fault exists, thereby creating fault classification data (*i.e.*, classification). In the claimed subject matter, the fault classification data is employed to estimate yield parameters of the wafer. Satya teaches estimating yield based on direct yield metrology data. Hsieh teaches identifying a tool fault condition based on wafer defect data. Neither Satya nor Hsieh teach or suggest generating fault classification data for an identified fault condition, and then using that fault classification data to estimate yield parameters. At most, Satya and Hsieh may teach fault detection, where Satya contemplates wafer fault detection and Hsieh contemplates tool fault detection. Neither contemplates fault classification or the subsequent estimating of yield parameters based on the fault classification data.

For these reasons, the Office Action has failed to establish a *prima facie* case of obviousness. The combination of Satya and Hseih fails to teach all features of the claimed subject matter as neither reference provides guidance as to estimate yield parameters based on fault classification data. Thus, the art of record fails to obviate claims 1-27 under 35 U.S.C. § 103(a). Applicants therefore respectfully request that the rejections be reversed.

B. SATYA, HSIEH, AND ATKINSON FAIL TO OBVIATE ANY CLAIM

Claims 9 and 22 were rejected under 35 U.S.C. § 103 as allegedly being obvious over Satya in view of Atkinson (U.S. Patent Publication No. 2004/0029029).

Claims 9 and 22 are allowable for at least the reasons provided above with respect to Satya and Hsieh. Atkinson fails to correct the defective teachings described above. Atkinson

merely teaches removing a faulty tool from service. Applicants therefore respectfully request that the rejections be reversed.

VIII. CLAIMS APPENDIX

The claims that are the subject of the present appeal – claims 1-27 – are set forth in the attached "Claims Appendix."

IX. EVIDENCE APPENDIX

There is no separate Evidence Appendix for this appeal.

X. RELATED PROCEEDINGS APPENDIX

There is no Related Proceedings Appendix for this appeal.

XI. CONCLUSION

The rejections fail because the cited art of record fails to teach all the limitations of the claims. More particularly, the art of record fails to teach receiving fault classification data associated with a tool fault condition that is associated with a process tool for processing a wafer and estimating at least one yield parameter of the wafer based on the fault classification data. Thus, the art of record fails to obviate claims 1-27 under 35 U.S.C. § 102 (e). Applicants therefore pray that the rejections be reversed and the claims be allowed to issue.

Respectfully submitted,

Date: June 29, 2007

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APPENDIX
(Claims at Issue)

1. A method, comprising:

receiving fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool for processing a wafer; and

estimating at least one yield parameter of the wafer based on the fault classification data.

2. The method of claim 1, wherein estimating the at least one yield parameter further comprises estimating an overall yield parameter.

3. The method of claim 2, wherein estimating the overall yield parameter further comprises estimating a number of die lost.

4. The method of claim 2, wherein estimating the overall yield parameter further comprises estimating a percentage of die lost.

5. The method of claim 1, wherein estimating the at least one yield parameter further comprises estimating a performance yield parameter.

6. The method of claim 5, wherein estimating the performance yield parameter further comprises estimating a speed yield parameter.

7. The method of claim 1, wherein estimating the at least one yield parameter further comprises associating at least one estimated yield parameter with a fault class specified by the fault classification data.

8. The method of claim 7, further comprising:

determining an actual yield parameter for the wafer; and

updating the estimated yield parameter based on the actual yield parameter.

9. The method of claim 1, further comprising removing the process tool associated with the tool fault condition from service responsive to the estimated yield parameter being outside a predetermined range.

10. The method of claim 1, further comprising scrapping the wafer responsive to the estimated yield parameter being outside a predetermined range.

11. The method of claim 1, further comprising:

determining process/step data associated with the tool fault condition; and

estimating at least one yield parameter based on the fault classification data and the process/step data.

12. The method of claim 11, further comprising estimating a plurality of yield parameters based on the fault classification data and the process/step data.

13. The method of claim 1, further comprising estimating a plurality of yield parameters based on the fault classification data.

14. A system, comprising:

a fault classification unit adapted to generate fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool for processing a wafer; and

a yield estimation unit adapted to estimate at least one yield parameter of the wafer based on the fault classification data.

15. The system of claim 14, wherein the at least one yield parameter further comprises an overall yield parameter.

16. The system of claim 15, wherein the overall yield parameter further comprises an estimated number of die lost.

17. The system of claim 15, wherein the overall yield parameter further comprises an estimated percentage of die lost.

18. The system of claim 14, wherein the at least one yield parameter further comprises a performance yield parameter.

19. The system of claim 18, wherein the performance yield parameter further comprises a speed yield parameter.

20. The system of claim 14, further comprising a yield estimation database adapted to store data associating at least one estimated yield parameter with a fault class specified by the fault classification data, wherein the fault estimation unit is further adapted to access the fault classification database to estimate the at least one yield parameter.

21. The system of claim 20, wherein the yield estimation unit is further adapted to receive an actual yield parameter for the wafer and update the estimated yield parameter based on the actual yield parameter.

22. The system of claim 14, wherein the yield estimation unit is further adapted to recommend removing the process tool associated with the tool fault condition from service responsive to the estimated yield parameter being outside a predetermined range.

23. The system of claim 14, wherein the yield estimation unit is further adapted to recommend scrapping the wafer responsive to the estimated yield parameter being outside a predetermined range.

24. The system of claim 14, wherein the yield estimation unit is further adapted to determine process/step data associated with the tool fault condition and estimate at least one yield parameter based on the fault classification data and the process/step data.

25. The system of claim 24, wherein the yield estimation unit is further adapted to estimate a plurality of yield parameters based on the fault classification data and the process/step data.

26. The system of claim 14, wherein the yield estimation unit is further adapted to estimate a plurality of yield parameters based on the fault classification data.

27. A system, comprising:

means for receiving fault classification data associated with a tool fault condition, the tool fault condition being associated with a process tool for processing a wafer; and

means for estimating at least one yield parameter of the wafer based on the fault classification data.